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(19)

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(54) IMPROVEMENTS IN SHEETING

(71) We, IMPERIAL METAL INDUSTRIES (KYNOCH) LIMITED, a British Company, of Kynoch Works, Witton, Birmingham B6 7BA, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to sheeting which is particularly, but not exclusively, intended for absorbing some of the energy of an explosion.

It has been found that when explosive materials are stored, there is a substantial risk that the accidental explosion of one explosive article can set fire to or explode others. A chain explosion can result in which the explosive stored is destroyed. Fire extinguishing systems, for example water sprays, are of assistance, but have little effect when the spread of the conflagration is by explosion rather than by flame and heat. It will also be appreciated that explosive substances contain their own oxygen supply so that the use of extinguishing gases similarly is of little use.

It is an object of the invention to provide sheeting which is capable of absorbing some of the energy of an explosion.

The present invention consists in sheeting comprising a layer of frame-resistant elastomer and a flexible reinforcing network comprising strands arranged side by side in the plane of the sheeting, each strand being in a zig-zag form and the strands being interlinked to form interstices of the network closed by said layer, so that the sheeting is relatively flexible about axes generally along the strands but is relatively resistant to flexing about axes transverse to the strands.

The flexible network may be of metal wire, and may be at least partially embedded in the layer.

Preferably there are provided two layers of elastomeric material secured one to each face of the network and to each other through interstices in the network.

The layers of elastomeric material may be bonded together by the use of adhesives or by being cured in contact with one another.

The elastomeric material may be based on chlorinated polyethylene and preferably contains at least 40 parts by weight per hundred parts by weight of rubber of filler material. It may also contain a flame retardant, preferably of the chlorinated paraffin type.

In accordance with the present invention also, a method of manufacturing sheeting comprises taking a flexible network which comprises strands arranged side by side, each strand being in a zig-zag form and the strand being interlinked to form interstices of the network, applying to each face of the network a layer of flame-resistant elastomeric material to form an assembly, placing the assembly between press-platens comprising faces of resiliently deformable material resistant to press conditions, closing the platens on the assembly, and applying pressure and heat to mould the sheets around the network, bond the sheets to the network and each other, and fully cure the elastomeric material of the sheets. The resiliently deformable material may be porous. Where non-porous resilient layers are used to face the platens, they will need replacement when distortion is induced by the networks. Parting agents may be used to ensure they separate from the layers of the sheeting.

Preferably, air is evacuated from within the assembly before closing the platens. Preferably also, the surfaces of the sheets that will contact each other and the network are coated with adhesive. The sheets may be partially cured before they are applied to the network, for example the elastomeric material may be at least half-cured before application to the network. If the elastomeric material is chlorinated polyethylene, the partial cure may be at 100—150°C for 120—5 minutes, and the press-cure 120—15 minutes at 130—180°C.

Preferably, the press pressure is at least 2 kg/cm^2, and it may be as high as 15 kg/cm^2.

An example of sheeting of the present invention will now be described with reference to the accompanying drawings in which:

Figure 1 is a plan view of a flexible wire network intended to be used to form the sheeting;

Figure 2 is a view similar to that of Figure 1 of the sheeting; and

Figure 3 is a cross-sectional view taken along the line 3—3 on Figure 2;

Figures 4 and 5 illustrate lengths of sheeting suspended for use.

Referring to the drawings, there is shown particularly in Figures 1 and 2 a flexible metal wire network comprising a plurality of parallel wire helices of which each one interlinks with the adjacent turns of its neighbours. Each turn of each helix is flattened sufficiently for the length thereof extending from one neighbouring helix to the other neighbouring helix to be substantially straight. The interlinking enables the helices to pivot readily with respect to one another about axes parallel to them. The network is therefore readily flexible in the direction perpendicular to the helices. However, the network is largely non-flexible in the direction parallel to the helices depending upon the stiffness of each individual flattened helix.

The wire network is cleaned and decreased and is then ready to be provided with two sheets of flame-resistant elastomeric material as shown in Figures 2 and 3.

Each sheet of elastomeric material in this example is chloro-sulphonated polyethylene and contains the filler materials listed below in the range of parts by weight per 100 parts by weight of rubber which are also given:

Silica	30—100,	preferably 60
Antimony trioxide	10—50,	preferably 25
Lead oxide	25—75,	preferably 40

To provide additional flame resistance, there may be added:

Chlorinated paraffin (e.g. Cereclor available from Imperial Chemical Industries Limited) 1—40, preferably 15, parts by weight.

The sheets are partially cured within the range of 30—120 minutes at 100—130°C to a stage which is more than half-cured. The required degree of partial cure is described below. The surfaces of the sheets that will contact each other and the network are then coated with adhesive which is preferably "Redux 120" available from Ciba-Geigy which is an emulsion of polyvinyl formal and phenolic resin in ethylene dichloride.

The partially-cured sheets of elastomeric material are applied to the faces of the network to produce an assembly, trapped air is evacuated from the assembly, and the assembly is placed between the platens of a press for the sheets to be pressed tightly against and over each face of the network to partially embed the wires and to make good contact with each other through the interstices in the network.

The press platens are faced with resiliently deformable foamed material resistant to press conditions, for example silicone rubber. The thickness of the foam is such that the uneven surface produced by the metal network is accommodated whilst a largely uniform pressure is exerted all over the elastomeric material independent of whether the elastomeric material is located on top of a metal wire, or within an interstice in the network. It is closely necessary for the elastomeric material to be partially cured in order that it can absorb inequalities of pressure without substantial change in its thickness. In this way the elastomeric material is shaped to embed the metal network but maintains a uniform thickness, and does not suffer substantial thinning over the wires of the metal network.

Curing then takes place under pressure, which for the composition given above would typically be at a temperature of 130—180°C for a time of 120—15 minutes at a pressure of at least 2 kg/cm^2. About 5 kg/cm^2 is satisfactory.

In this way there is produced an area of sheeting in which the elastomeric material is closely moulded over the underlying network, and which is readily flexible in one direction but not in the other direction. The sheeting has substantial strength governed principally by the selection of the metal and gauge of the wire. Normally it is found that mild steel wire having a diameter of 2.5 mm with interstices of about 4 sq cm. is adequate for most duties. The sheeting is inexpensive and relatively lightweight.

In use, the sheeting is arranged between adjacent explosive materials, and typically in the case of stored rocket motors, is provided as an enclosure around each individual one. The accidental explosion of one rocket motor may cause the explosion of another motor, but the sheet is deflected by the blast and absorbs a large proportion of it in order significantly to reduce the chances of an adjacent rocket motor being exploded. The ability to absorb energy is believed, without prejudice to the present invention, to arise from the deformability of the sheeting, whilst the rubbery material has high hysteresis losses and the

deformation thereof in shear at the interlinking points of the wire network readily absorbs substantial amounts of energy. The elastomeric material is not incombustible, but will resist fire for sufficient time for normal fire extinguishing systems to suppress any flames that are present. It is important that the metal network should be kept at a sufficiently low temperature to avoid loss of strength, and this is provided by the elastomeric material. For this reason the thickness of the elastomeric material should not be substantially reduced over the metal wires.

Preferably a bond is formed between the elastomer and the wire to inhibit the spread of a tear passed the wire defining an interstice. The resilience of the sheeting will then permit material adjacent the tear to spring back after passage of a fragment through the sheeting. The interlinking of the strands will prevent the network disintegrating even if some of the links are broken by a fragment passing through. The size of the interstices is selected to permit fragments of a given size to pass through without breaking strands of the network. A suitable minimum size is 4 sq cm. smaller sizes resulting in increased weight of the sheeting. The interstices might be as large as 36 sq cm but strength is lost with increasing size.

A suitable wire gauge is of the order of 2 1/2 mm. The network may be flattened, for example by rolling it down. The depth of the flattened network will usually be in the range 2—4 times the thickness of the wire, for example in the range 6—10 mm. Alternative materials for the network are fibreglass, carbon fibre and Kevlar. However, these material may not provide sufficient fire resistance for all circumstances and can only be used where high fire resistance is not required.

The elastomer layers should be as thin as possible consistent with the required fire resistance, thermal insulation and resilience. It is unlikely that layers less than 1/2 mm. thick will provide the required properties, and 1 1/2 mm is usually satisfactory. Suitable elastomers include ethylene-propylene terpolymers and copolymers, butyl rubbers, styrene-butadiene rubbers and nitrile-butadiene rubbers. In general, any elastomer which is tough, fire-resistant and adhesive to a sheet of the same material will be satisfactory. Oil resistance may also be required in some circumstances.

At least 40 parts by weight per hundred parts by weight of rubber of a filler material may be provided, and this 40 parts may include a mixture of filler materials. The main filler may be provided to give strength, and may comprise one or more of silica, asbestos, carbon black, clay and other conventional strengthening fillers. An auxiliary filler may provide some strength and some fire retarding properties, for example antimony trioxide. Some auxiliary fillers may be provided only to give fire retardance, for example chlorinated paraffin. Lead oxide referred to above is a curing agent for chloro-sulphonated polyethylene and may not be required with other elastomers.

Preferably, the sheeting is suspended for use, and it may be combined with suspension means which preferably cooperate with a substantial portion of the interstices at the edge of the sheet. The suspension means may comprise a rod passed through the edge of the network. Alternatively, hook bolts may be provided to pass through respective interstices. The sheeting may be suspended at opposite longitudinal edges with the strands extending generally horizontally. Alternatively, it may be suspended at opposite end edges with the strands extending generally vertically.

Figures 4 and 5 illustrate somewhat diagrammatically suitable suspension arrangements. In Figure 4, the numeral 10 indicates vertical supports forming a part of a rack system. Explosive materials may be stored on the racks which extend generally horizontally. Respective storage spaces 12 are defined by lengths 14 of sheeting in accordance with the invention. The strands in the sheets 14 extend generally horizontally, and each sheet is suspended from a pair of rods 16 attached in any suitable manner to the supports 10. Each rod 16 is linked with the edge strand of the sheet by passing it through each of the turned-over portions of the strand. The strands permit the sheet to flex about axes extending longitudinally of the sheet, but there is substantial rigidity about axes transverse to the strands. The rods 16 supporting the lower sheet 14 are located adjacent the lowermost part of the upper sheet 14, so that an individual storage space 12 is defined between two adjacent sheets.

Alternatively, where the sheeting is to be used in storage of elongate articles which are vertical, it may be suspended at an end edge, such as the edge 18 of the sheet 20 shown in Figure 5. In this case, the strands will extend substantially vertically, and the sheet will be permitted to flex about substantially vertical axes, but will resist flexing about substantially horizontal axes. The suspension means may be similar to that described above. In each case, the suspension rod is connected to the strand(s) at intervals along its length, for example by bolts (not shown). The suspension rods may be incorporated in the network prior to

embedding of the latter in the elastomeric sheets.

An alternative suspension means comprises hook bolts passed through individual interstices of the network. Preferably, the suspension means cooperates with each edge interstice, however, and the single suspension rod is preferred to the hook belts.

It will be appreciated that the sheeting will have other uses, for example in the field of generally confining explosions and fire conditions. It may also be useful in acoustic attenuation.

It is desirable to maintain at least a minimum thickness of elastomer over the wires of the network during the embedding step. Preferably, the thickness of each layer is maintained approximately uniform during embedding, but this is not essential if the required minimum thickness is retained.

The words Cereclor, Redux and Kevlar are Registered Trade Marks.

WHAT WE CLAIM IS:—

1. Sheeting comprising a layer of flame-resistant elastomer and a flexible, reinforcing network comprising strands arranged side by side in the plane of the sheeting, each strand being is a zig-zag form and the strands being interlinked to form interstices of the network closed by said layer, so that the sheeting is relatively flexible about axes generally along the strands but relatively resistant to flexing about axes transverse to the strands.

2. Sheeting as claimed in claim 1 wherein the network is of metal wire.

3. Sheeting as claimed in claim 1 or claim 2 wherein the interstices are at least 4 sq cm in area.

4. Sheeting as claimed in any preceding claim wherein the elastomer is selected from ethylene-propylene terpolymers and copolymers, butyl rubbers, styrene-butadiene rubbers, nitrile-butadiene rubbers and chloro-sulphonated polyethylene.

5. Sheeting as claimed in any preceding claim wherein the elastomer includes a filler material in a quantity of at least 40 parts by weight per hundred parts by weight of rubber.

6. Sheeting as claimed in claim 5 wherein the filler comprises one or more materials selected from silica, asbestos, carbon black, and clay.

7. Sheeting as claimed in claim 5 or claim 6 wherein the filler includes a flame-retardant material.

8. Sheeting as claimed in any preceding claim combined with means for suspending sheeting in use.

9. Sheeting as claimed in claim 8 wherein said suspension means comprises a rod interlinked with a substantial portion of the edge interstices of the sheet.

10. Storage means comprising sheeting as claimed in any preceding claim suspended to at least partially define a storage space.

11. Storage means as claimed in claim 10 wherein the sheeting is suspended at longitudinal edges which extend in the same general direction as the strands.

12. Storage means as claimed in claim 10 wherein the sheeting is suspended at end edges which extend transverse to the strands.

13. A method of manufacturing sheeting comprising taking a flexible network which comprises strands arranged side by side, each strand being in a zig-zag form and the strands being interlinked to form interstices of the network, applying to each face of the network a layer of flame-resistant elastomeric material to form an assembly, placing the assembly between press-platens comprising faces of resiliently deformable material resistant to press conditions, closing the platens on the assembly, and applying pressure and heat to mould the sheets around the network, bond the sheets to the network and each other, and fully cure the elastomeric material of the sheets.

14. A method as claimed in claim 13 wherein the resiliently deformable material is porous.

15. A method as claimed in claim 13 or claim 14 wherein air is evacuated from the assembly before closing of the platens.

16. A method as claimed in any of claims 13 to 15 wherein the surfaces of the sheets that will contact each other and the network are coated with adhesive.

17. A method as claimed in any of claims 13 to 16 wherein the sheets are partially cured before they are applied to the network.

18. Sheeting substantially as hereinbefore described with reference to Figures 1 to 3 of the accompanying drawings.

19. Storage means substantially as hereinbefore described with reference to Figures 4 and 5 of the accompanying drawings.

20. A method of producing sheeting substantially as hereinbefore described with reference to Figures 1 to 3 of the accompanying drawings.

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1467470 COMPLETE SPECIFICATION

2 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

FIG. 1

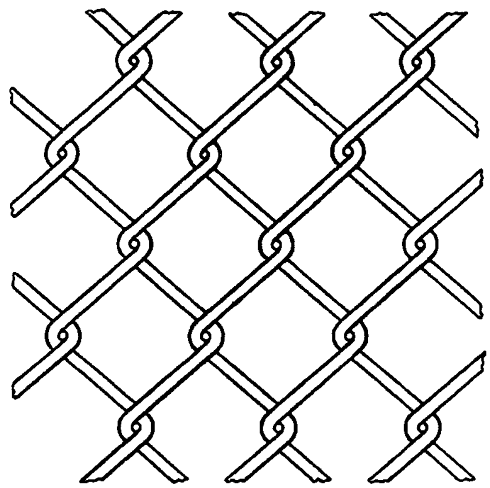


FIG. 2

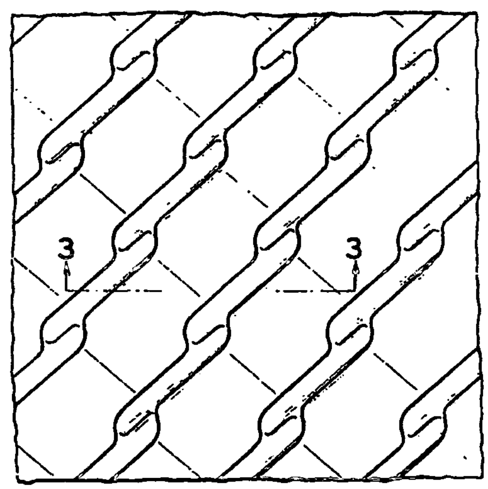
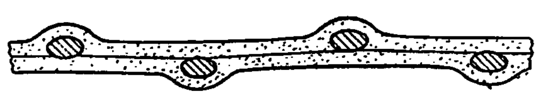


FIG. 3



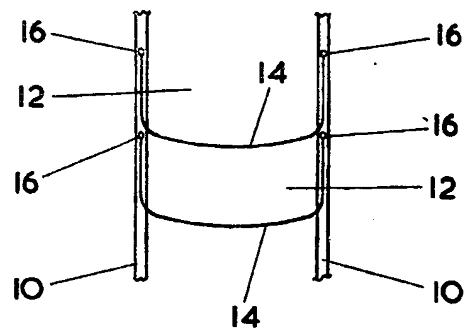


FIG. 4

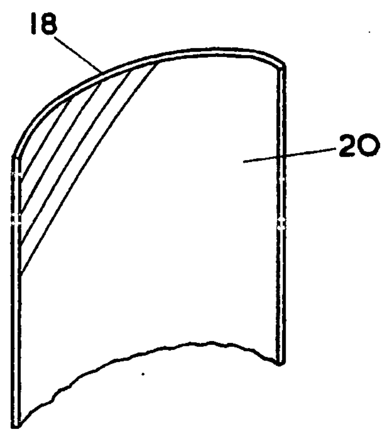


FIG. 5